US009128120B2

(12) **United States Patent**
Lee

(10) **Patent No.: US 9,128,120 B2**
(45) **Date of Patent: Sep. 8, 2015**

(54) **PROBE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 304 days.

(21) Appl. No.: **13/807,108**

(22) PCT Filed: **Sep. 10, 2010**

(86) PCT No.: **PCT/KR2010/006168**
§ 371 (c)(1),
(2), (4) Date: **Dec. 27, 2012**

(87) PCT Pub. No.: **WO2012/002612**
PCT Pub. Date: **Jan. 5, 2012**

(65) **Prior Publication Data**

US 2013/0099811 A1 Apr. 25, 2013

(30) **Foreign Application Priority Data**

Jun. 30, 2010 (KR) 10-2010-0063058

(51) **Int. Cl.**
G01R 1/067 (2006.01)
G01R 1/04 (2006.01)

(52) **U.S. Cl.**
CPC ***G01R 1/067*** (2013.01); ***G01R 1/06722*** (2013.01); *G01R 1/0483* (2013.01)

(58) **Field of Classification Search**
USPC 324/754.11
See application file for complete search history.

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(57) **ABSTRACT**

Disclosed is a probe which stably transmits a test signal. The probe electrically connects a semiconductor device and a tester for testing the semiconductor device. The probe may include an upper plunger which is configured to be electrically connected to the semiconductor device; a lower plunger which is configured to be electrically connected to the tester; an elastic member which is disposed between the upper plunger and the lower plunger, and elastically biases the upper and lower plungers to have them spaced from each other; a conductive member which is disposed in an inside or outside of the elastic member and electrically connects the upper plunger and the lower plunger; and a barrel which accommodates therein the upper plunger, the lower plunger, the elastic member and the conductive member.

5 Claims, 9 Drawing Sheets

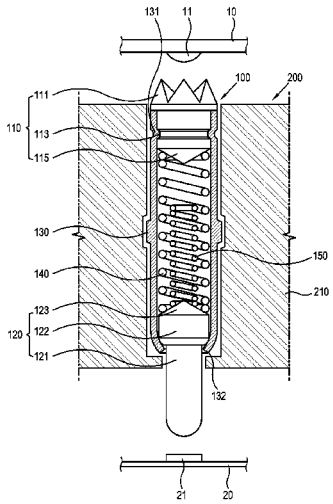

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FIG. 1

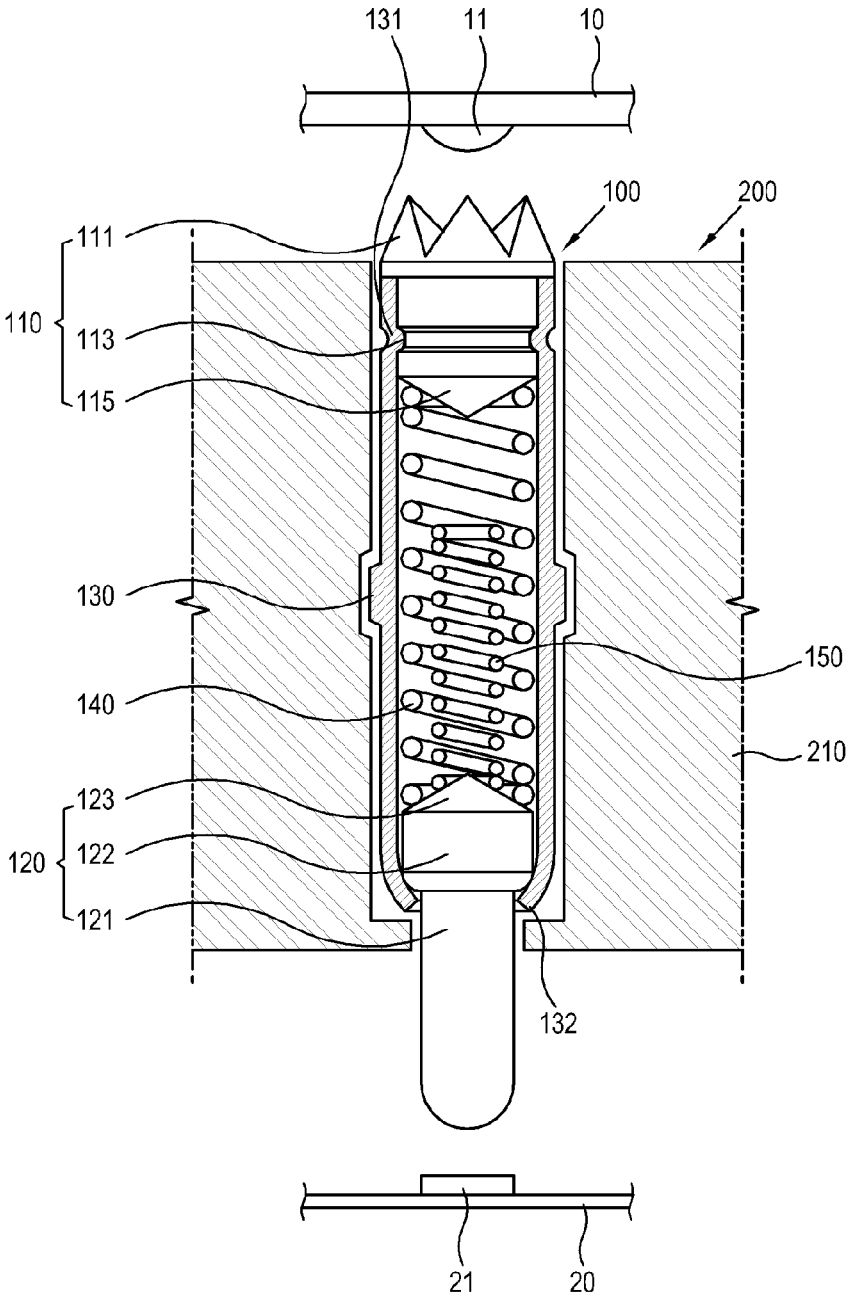

131
11
10
100
200
111
110
113
115
130
150
140
210
123
120
122
121
132
21
20

FIG. 2

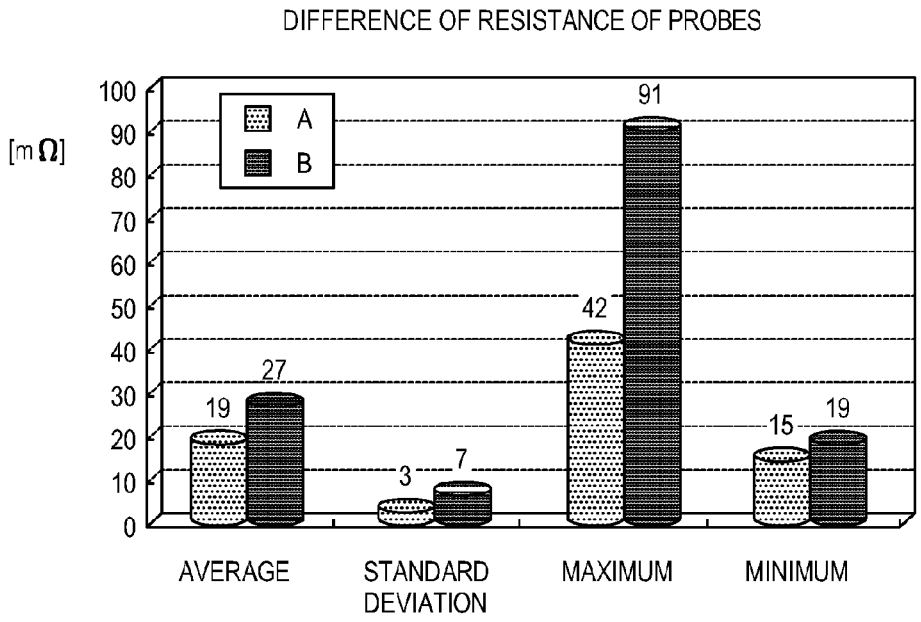

DIFFERENCE OF RESISTANCE OF PROBES
[mΩ]
100
90
80
70
60
50
40
30
20
10
0
A
B
19
27
3
7
42
91
15
19
AVERAGE
STANDARD DEVIATION
MAXIMUM
MINIMUM

FIG. 3

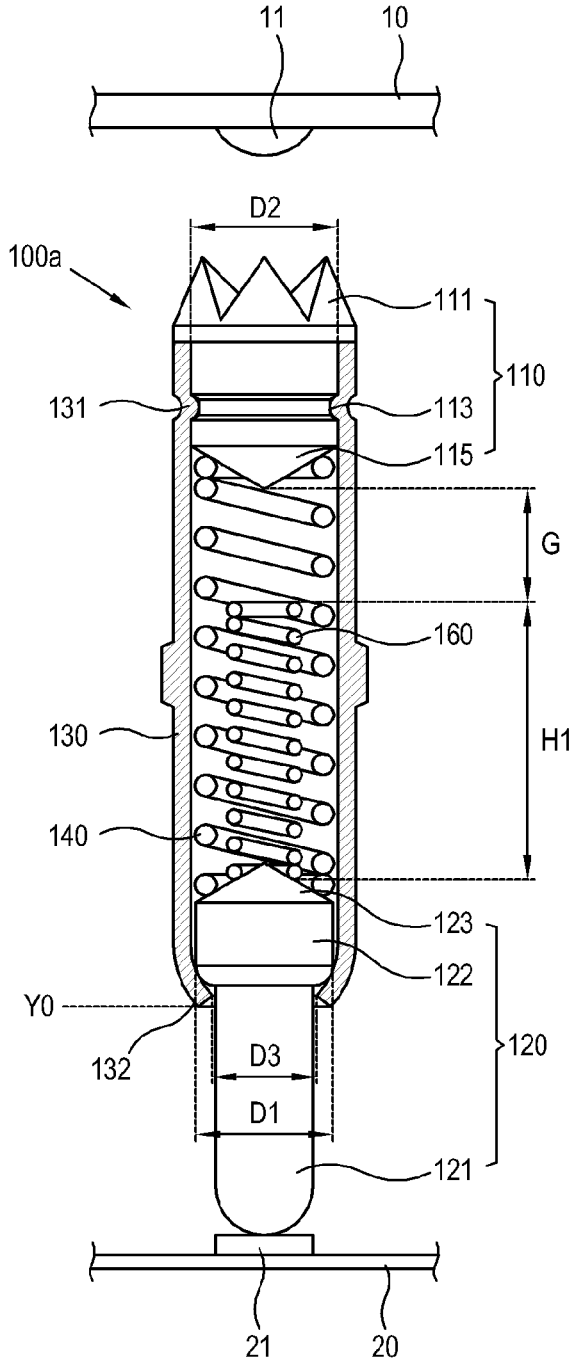

11
10
D2
100a
111
110
131
113
115
G
160
H1
130
140
123
122
Y0
132
D3
D1
120
121
21
20

FIG. 4

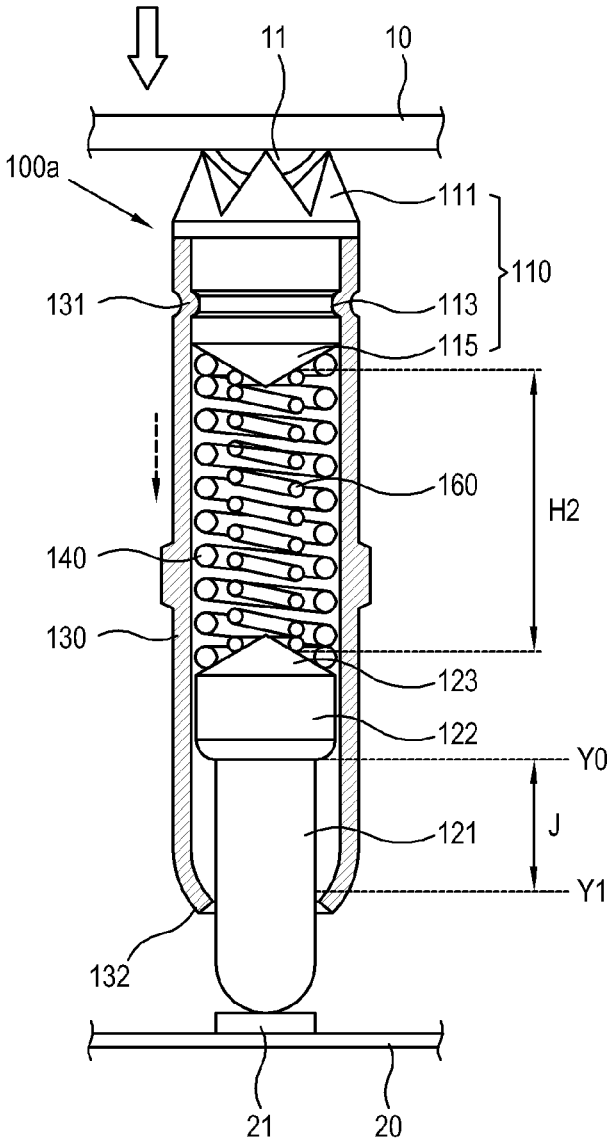

11
10
100a
111
110
131
113
115
160
H2
140
130
123
122
Y0
121
J
Y1
132
21
20

FIG. 5

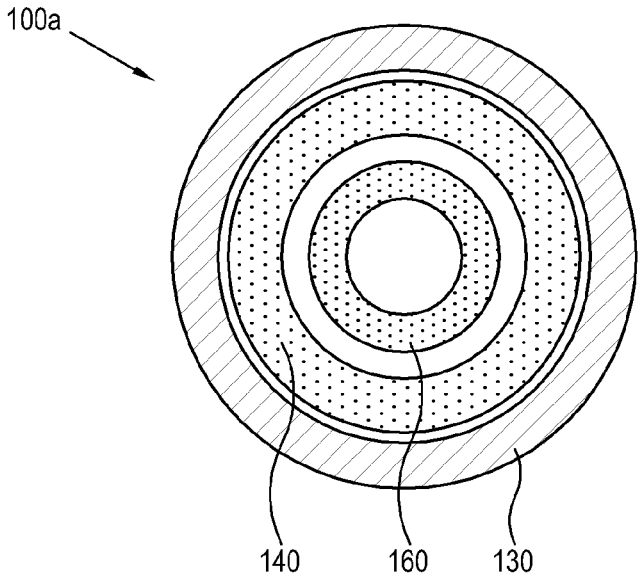


FIG. 6

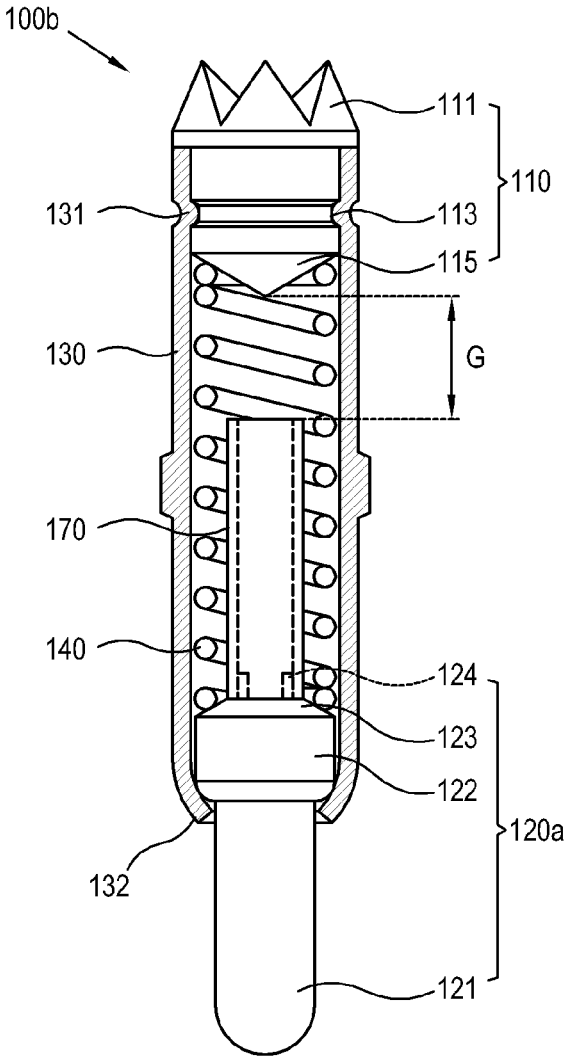


FIG. 7

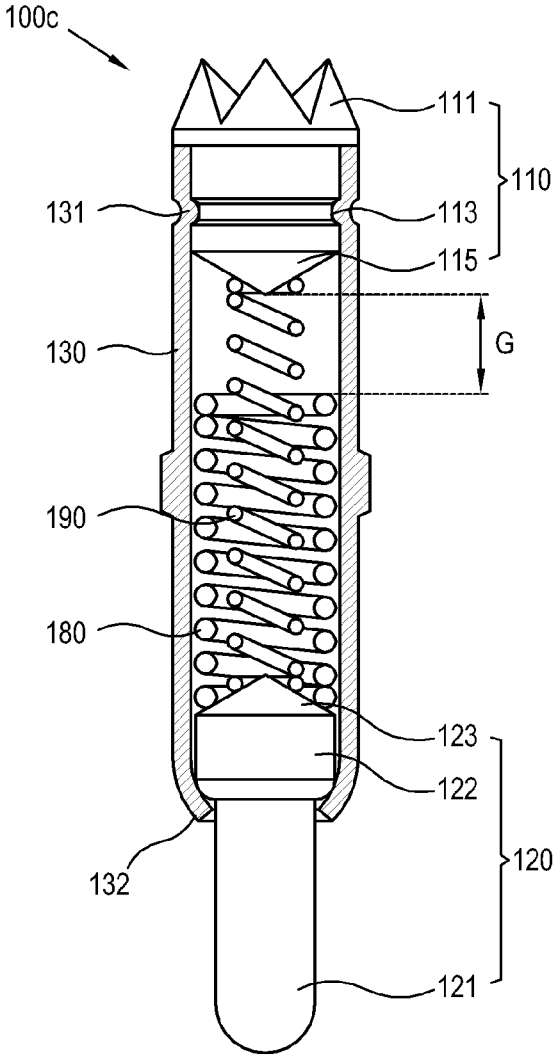


FIG. 8

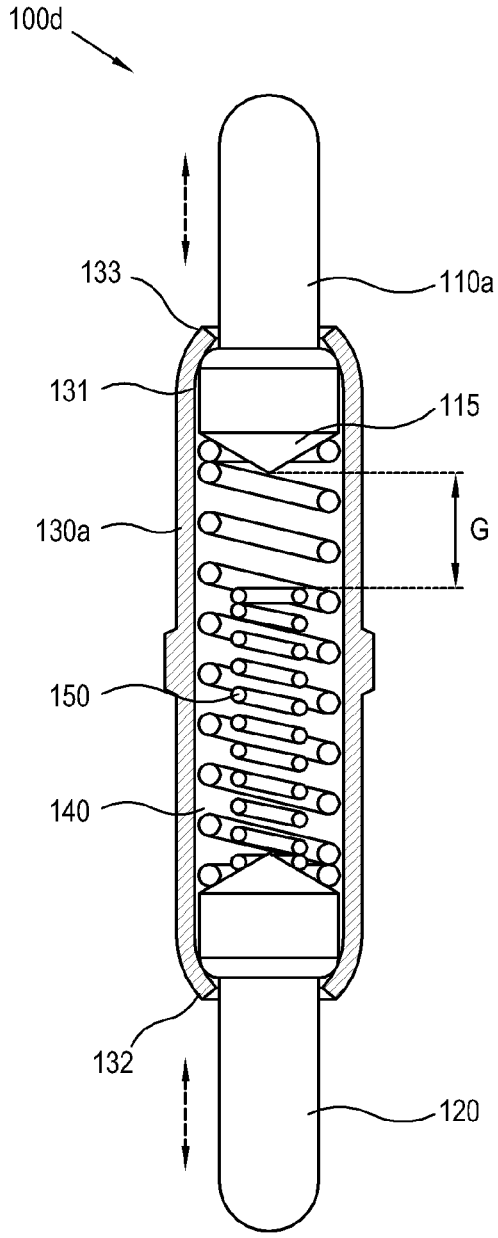
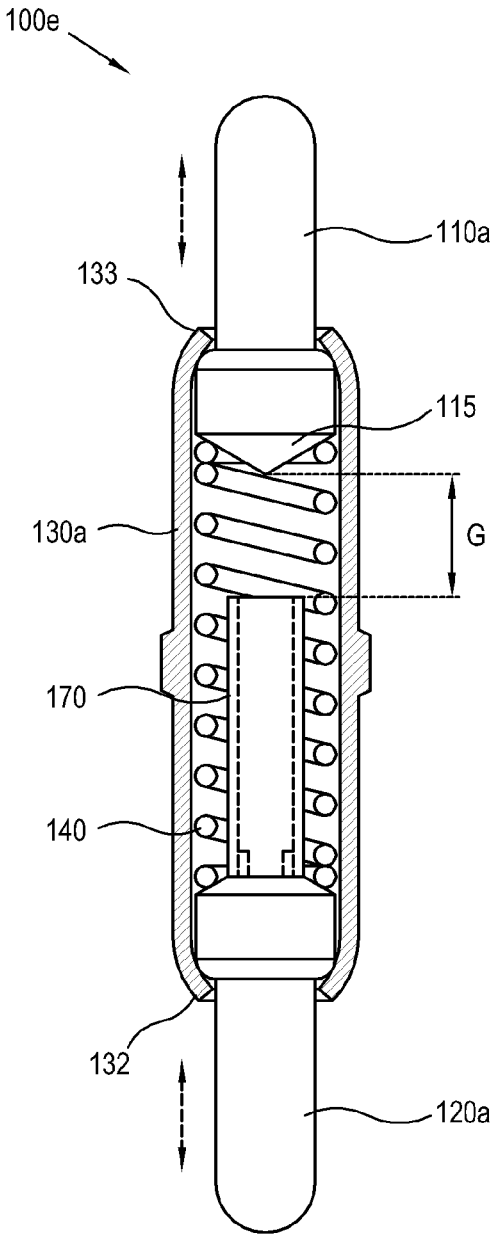


FIG. 9



PROBE

BACKGROUND

1. Field

Apparatuses and methods consistent with the exemplary embodiments relate to a probe, and more particularly, to a probe which stably transmits a test signal.

2. Description of the Related Art

A semiconductor device such as a semiconductor chip or a wafer undergoes a predetermined test to be tested for its quality.

A test socket or a probe card is used to electrically connect a tester testing the quality of a semiconductor device such as a semiconductor chip or a wafer by applying a predetermined test signal, and the semiconductor device.

The test socket or the probe card has a probe provided therein to apply the predetermined test signal to a solder ball of the semiconductor device or a pad.

A first end and a second end of the probe are connected to the semiconductor device and a load board of the tester, respectively, to electrically connect the semiconductor device and the tester.

The probe transmits the test signal (current or voltage) to the semiconductor device, and it is very important to stably transmit the test signal.

SUMMARY

Accordingly, one or more exemplary embodiments provide a probe which stably transmits a test signal.

Another exemplary embodiment is to provide a probe which has a simple configuration and improves conductivity.

Another exemplary embodiment is to provide a probe which reduces test costs.

The foregoing and/or other aspects may be achieved by providing by a probe which electrically connects a semiconductor device and a tester for testing the semiconductor device, the probe including: an upper plunger which is configured to be electrically connected to the semiconductor device; a lower plunger which is configured to be electrically connected to the tester; an elastic member which is disposed between the upper plunger and the lower plunger, and elastically biases the upper and lower plungers to have them spaced from each other; a conductive member which is disposed in an inside or outside of the elastic member and electrically connects the upper plunger and the lower plunger; and a barrel which accommodates therein the upper plunger, the lower plunger, the elastic member and the conductive member.

The conductive member may electrically connect the upper and lower plungers only when at least one of the upper plunger and the lower plunger moves toward the other one of the upper plunger and the lower plunger.

The conductive member may selectively contact at least one of the upper plunger and the lower plunger.

The conductive member may apply an elastic force to at least one of the upper plunger and the lower plunger to have them spaced from each other.

Effects of the Invention

The conductive member may comprise at least one of a conductive coil spring and a conductive rubber.

As described above, a probe according to the present invention has the following effects:

1) a test signal may stably be transmitted as an additional conductive member is provided in the probe;

2) a relatively simple configuration is available and conductivity may improve; and

3) test costs may be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other aspects will become apparent and more readily appreciated from the following description of the exemplary embodiments, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic sectional view of a probe and a test socket accommodating the probe therein according to a first exemplary embodiment of the present invention;

FIG. **2** illustrates a graph for comparison of resistance in the probe according to the first exemplary embodiment of the present invention;

FIGS. **3** and **4** are longitudinal sectional views of a probe before and after receiving an external force according to a second exemplary embodiment of the present invention;

FIG. **5** is a cross-sectional view of the probe in FIG. **3**;

FIG. **6** is a schematic longitudinal sectional view of a probe according to a third exemplary embodiment of the present invention;

FIG. **7** is a schematic longitudinal sectional view of a probe according to a fourth exemplary embodiment of the present invention;

FIG. **8** is a schematic longitudinal sectional view of a probe according to a fifth exemplary embodiment of the present invention; and

FIG. **9** is a schematic longitudinal sectional view of a probe according to a sixth exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Below, exemplary embodiments will be described in detail with reference to accompanying drawings so as to be easily realized by a person having ordinary knowledge in the art. The exemplary embodiments may be embodied in various forms without being limited to the exemplary embodiments set forth herein. Descriptions of well-known parts are omitted for clarity, and like reference numerals refer to like elements throughout.

As shown in FIG. **1**, a probe **100** according to a first exemplary embodiment of the present invention includes an upper plunger **110**; a lower plunger **120**; an elastic member **140** elastically biasing the upper and lower plungers **110** and **120** to have them spaced from each other; a conductive member **150** provided within the elastic member **140**; and a barrel **130** accommodating therein the upper and lower plungers **110** and **120**, the elastic member **140** and the conductive member **150**.

The upper plunger **110** includes a tip **111** contacting a solder ball **11** of a semiconductor device **10**; a groove **113** formed in an external circumference of the upper plunger **110**; and an elastic member contact **115** contacting the elastic member **140**.

An external diameter of the tip **111** may be larger than an internal diameter of the barrel **130**. A user may fix the upper plunger **110** to the barrel **130** by pushing the upper plunger **110** to the barrel **130** until the groove **113** holds a projection **131** of the barrel **130** (to be described later).

FIG. **1** illustrates the tip **111** which is shaped like a crown with a plurality of triangular pyramids formed thereon, but the shape of the tip **111** is not limited thereto. Alternatively,

the shape of the tip **111** may vary depending on the shape of a contacting target. For example, if the semiconductor device **10** includes a semiconductor chip in a ball grid array, the tip **111** may be shaped like a crown as above. Also, the tip **111** may have an A-shape having a single sharp tip or a dimple shape whose inside is concave to insert the solder ball **11** thereinto. Further, the tip **111** may be shaped like a hemisphere such as a tip **121** of the lower plunger **120** (to be described later) if the contacting target is a pad.

The groove **113** of the upper plunger **110** is coupled to the projection **131** of the barrel **130**. The upper plunger **110** is coupled to the barrel **130** so that the upper plunger **110** does not move up and down and is adhered thereto.

The elastic member contact **115** may be shaped like a cone protruding toward the lower plunger **120**. In some cases, the elastic member contact **115** may be shaped like a cylinder into which the elastic member **140** is inserted. The elastic member contact **115** may have other various shapes as long as it may maintain a contact with the elastic member **140**.

The upper plunger **110** may be formed as a single body.

The lower plunger **120** includes the tip **121** which contacts the pad **21** of the load board **20** of the tester; a main body **122** which is held by the tip **132** of the barrel **130**; and an elastic member contact **123** which contacts the elastic member **140**.

The tip **121** may be shaped like a hemisphere to easily contact the pad **21**.

An external diameter D1 of the main body **122** is larger than an internal diameter D3 of the tip **132** of the barrel **130** and smaller than an internal diameter D2 of the barrel **130**. Accordingly, the lower plunger **120** may be inserted through a second end of the barrel **130**, and the main body **122** is held by the tip **132** so that the lower plunger **120** is not separated toward the load board **20**.

The elastic member contact **123** may be shaped like a cone which protrudes toward the upper plunger **110**. Otherwise, the elastic member contact **123** may be shaped like a cylinder into which the elastic member **140** may be inserted. The elastic member contact **123** may have other various shapes as long as it may maintain a contact with the elastic member **140**.

The lower plunger **120** may be formed as a single body.

The barrel **130** accommodates therein the upper plunger **110**, the lower plunger **120**, the elastic member **140** and the conductive member **150**.

The barrel **130** may be shaped like a cylinder whose upper side is open for the upper plunger **110** to be inserted thereinto.

The barrel **130** includes a projection **131** which is held by the groove **113** of the upper plunger **110**; and the tip **132** which prevents the lower plunger **120** from being separated downward. If an external force larger than an elastic bias of the elastic member **140** is applied, the lower plunger **120** may move toward the upper plunger **110**. The tip **132** acts as a stopper which regulates the downward movement of the lower plunger **120**.

The barrel **130** accommodates therein the upper and lower plungers **110** and **120** to expose the tip **111** of the upper plunger **110** and the tip **121** of the lower plunger **120** to the outside.

The elastic member **140** is disposed between the upper plunger **110** and the lower plunger **120**, and elastically biases the upper and lower plungers **110** and **120** to have them spaced from each other.

The elastic member **140** may include a conductive metal.

The conductive member **150** electrically connects the upper plunger **110** and the lower plunger **120**.

A first end of the conductive member **150** contacts the elastic member contact **115** of the upper plunger **110**, and a second end of the conductive member **150** contacts the elastic member contact **123** of the lower plunger **120**.

The first end and the second end of the conductive member **150** maintain the contact with the elastic member contacts **115** and **123**, regardless of the upward and downward movement of the lower plunger **120**.

The conductive member **150** may apply an elastic force to at least one of the upper and lower plungers **110** and **120** in the direction in which the upper and lower plungers **110** and **120** are spaced from each other. As shown in FIG. **1**, the conductive member **150** may be shaped like a coil spring. An external diameter of the conductive member **150** is smaller than an internal diameter of the elastic member **140**. Thus, the conductive member **150** may be accommodated in the elastic member **140**.

The conductive member **150** may include a conductive metal. In some case, the conductive member **150** may include a conductive rubber or a conductive plastic. The conductive rubber may have conductive properties as a non-conductive material such as silicon includes a plurality of conductive metal balls therein. The material of the conductive member **150** is not limited to the foregoing, and may include other various materials as long as it is conductive.

The conductive member **150** preferably has an electric conductivity equal to or higher than that of the barrel **130**. The barrel **130** acts as a casing which accommodates the plungers **110** and **120**, the elastic member **140** and the conductive member **150** and conducts electricity. Thus, a material which has a highly mechanical strength and good electric conductivity may be used for the barrel **130**.

The conductive member **150** may be made of a material which has an electric conductivity equal to or higher than that of the elastic member **140**.

The conductive member **150** may include the same material as the upper and lower plungers **110** and **120**.

With the foregoing configuration, the probe **100** is accommodated in a socket housing **210**.

The socket housing **210** accommodates therein, and supports, the probe **100** to expose the tip **111** of the upper plunger **110** and the tip **121** of the lower plunger **120** to the outside.

If a handler (not shown) which grips the semiconductor device **10** presses the semiconductor device **10** downward and has the solder ball **11** of the semiconductor device **10** contact the upper plunger **110**, a test signal (current) is transmitted from the load board **20** to the semiconductor device **10** through the lower plunger **120** and the load board **20** which contact each other. Any shock which may arise from the downward pressure of the semiconductor device **10** may be absorbed by the elastic member **140**.

The test signal (current) which is applied by the load board **20** of the tester is transmitted to the solder ball **11** of the semiconductor device **10** through the upper plunger **110** according to the following three paths:

1) First Path: the lower plunger **120** contacting the pad **21**→the elastic member **140**→the upper plunger **110**;
2) Second Path: the lower plunger **120**→the conductive member **150**→the upper plunger **110**; and
3) Third Path: the lower plunger **120** by the contact of the main body **122** of the lower plunger **120** and the tip **132** of the barrel **130**→the barrel **130**→the upper plunger **110**.

The above three paths have the same configuration as a closed circuit which has three parallel circuits. Thus, the entire resistance value of the probe **100** is significantly reduced to stably transmit the test signal.

In the first exemplary embodiment of the present invention, the upper plunger **110** is adhered to the barrel **130**, and the

lower plunger **120** moves up and down with respect to the barrel **130**, but not limited thereto. Alternatively, the upper plunger **110** may move up and down and the lower plunger **120** may be adhered to the barrel **130**.

FIG. **2** illustrates a graph which compares resistance values of the probe **100** according to the first exemplary embodiment of the present invention and a probe which does not have a conductive member **160** therein.

As shown in FIG. **1**, the conductive member **160** includes a coil spring. The test was conducted for 100 probes, respectively.

For each probe, the total resistance value between the upper plunger and the lower plunger was measured, and the average and a standard deviation were calculated. The total resistance value means the sum of the resistance values from the three signal transmitting paths between the lower plunger and the upper plunger.

If the conductive material **160** does not exist ('B' in [Table 1]), the resistance value (mΩ) measured from 100 probes is maximum 90.8, minimum 18.9, average 27.3 and has a standard deviation of 7.0.

According to the first exemplary embodiment of the present invention, if the conductive member **160** exists ('A' in [Table 1]), the resistance value (mΩ) measured from the same number of probes is maximum 41.6, minimum 15.0, average 19.3 and has a standard deviation of 3.1.

The foregoing is summarized as a table as follows.

TABLE 1

Measured Resistance [mΩ]	Average	Standard deviation	Maximum	Minimum
A	19.3	3.1	41.6	15.0
B	27.3	7.0	90.8	18.9

In summary, according to the first exemplary embodiment of the present invention, if the conductive member **160** is provided in the probe **100**, the average resistance value decreases by approximately 30% and the standard deviation by 55% or more. That is, the probe **100** according to the first exemplary embodiment has a more stable resistance value and thus stably transmits the test signal between the tester and the semiconductor device.

As shown in FIGS. **3** to **5**, a probe **100***a* according to a second exemplary embodiment of the present invention includes the upper plunger **110**; the lower plunger **120**; the elastic member **140**; the conductive member **160**; and the barrel **130**.

In case of the conductive member **150** according to the first exemplary embodiment of the present invention, opposite ends of the conductive member **150** contact the upper and lower plungers **110** and **120**, respectively. Meanwhile, at least one of opposite ends of the conductive member **160** according to the present exemplary embodiment does not contact the upper and lower plungers **110** and **120**.

FIGS. **3** and **4** illustrate the conductive member **160** whose first end is spaced not to contact the upper plunger **110**. However, opposite ends of the conductive member **160** may be spaced from the upper and lower plungers **110** and **120** and not in contact with them. In this case, the conductive member **160** may be supported by the barrel **130** through a connector (not shown) connected to the barrel **130**.

As shown in FIG. **5**, the conductive member **160** may be accommodated in the elastic member **140** since an external diameter of the conductive member **160** is smaller than an internal diameter of the elastic member **140**.

A first end of the conductive member **160** is spaced from the upper plunger **110** as much as a predetermined gap G, and a second end thereof contacts the lower plunger **120**.

Returning to FIG. **3**, unless the semiconductor device **10** moves downward and the solder ball **11** contacts the upper plunger **110** and applies an external force to the probe **100***a*, the upper plunger **110** and the lower plunger **120** are spaced from each other by the elastic member **140**. Accordingly, at least one of the opposite ends of the conductive member **160** is spaced from the upper and lower plungers **110** and **120** and does not contact them.

The conductive member **160** has a length H**1** when not pressed.

A gap between the upper plunger **110** and the lower plunger **120** is G+H**1**.

As shown in FIG. **4**, if an external force is applied to the probe **100***a*, the upper plunger **110** and the lower plunger **120** move and approach each other by overcoming the elastic bias of the elastic member **140**. More specifically, since the upper plunger **110** is adhered to the barrel **130** and the lower plunger **120** is supported by the load board **20**, the elastic member **140** is compressed and the upper plunger **110** and the barrel **130** move downward. Then, the elastic member contact **115** of the upper plunger **110** contacts the conductive member **160**. Accordingly, the test signal (current) is transmitted from the load board **20** to the semiconductor device **10** through the conductive member **160**, the elastic member **140** and the upper plunger **110**.

That is, according to the second exemplary embodiment, the conductive member **160** simultaneously contacts the upper plunger **110** and the lower plunger **120** only when the semiconductor device **10** is being tested. If the test is not conducted, the conductive member **160** is spaced from both the upper and lower plungers **110** and **120** or from at least one of them and does not contact.

As the barrel **130** moves downward by a downward pressure of the semiconductor device **10**, an internal side of the barrel **130** and an external surface of the lower plunger **120** contact each other, and a current transmitting path of the lower plunger **120**, the barrel **130** and the upper plunger **110** is formed. Also, the path of the lower plunger **120**, the elastic member **140** and the upper plunger **110**, and the path of the lower plunger **120**, the conductive member **160** and the upper plunger **110** are formed. Thus, the test signal may be transmitted more stably.

A movement distance J of the barrel **130** before and after the application of the external force is the same as the predetermined gap G between the conductive member **160** and the upper plunger **110** or larger than the gap G. The movement distance J falls under a difference between a location Y**0** before the application of the external force to the tip **132** of the barrel and a location Y**1** after the application of the external force.

That is, a gap H**2** between the upper plunger **110** and the lower plunger **120** after the application of the external force is the same as the length H**1** of the conductive member **160** or smaller than that (H**2**<H**1**).

As shown in FIG. **6**, a probe **110***b* according to a third exemplary embodiment of the present invention includes the upper plunger **110**; the lower plunger **120**; the elastic member **140**; a conductive member **170**; and a barrel **130** which accommodates the foregoing elements.

The conductive member **160** according to the second exemplary embodiment includes a coil spring, but the conductive member **170** according to the third exemplary embodiment may include a cylindrical tube, but not limited thereto. Alternatively, the conductive member **170** according

to the present exemplary embodiment may have various shapes, e.g., triangular, rectangular or other polygonal shapes or an elliptical shape.

The lower plunger **120** may further include a projection **124** which protrudes toward the conductive member **170**. The conductive member **170** which is shaped like a bar may pressedly be inserted into the projection **124**.

The conductive member **170** may include a thin and highly conductive metal.

The conductive member **170** may include a conductive synthetic resin. The conductive synthetic resin may include a silicon resin or rubber having a plurality of metal balls therein to be conductive. The conductive member **170** may vary as long as it is conductive.

A projection (not shown) may be formed in the conductive member **170** and an insertion part (not shown) may be formed in the lower plunger **120** to pressedly insert the projection thereinto. The insertion part may include a groove or a projection.

As shown in FIG. **7**, a probe **100***c* according to a fourth exemplary embodiment of the present invention includes the upper plunger **110**; the lower plunger **120**; an elastic member **190**; a conductive member **180**; and the barrel **130** which accommodates therein the foregoing elements.

Opposite ends of the elastic member **190** contact the upper and lower plungers **110** and **120** and elastically biases the plungers **110** and **120** to have them spaced from each other.

The conductive member **180** is provided in an outside of the elastic member **190**. That is, an internal diameter of the conductive member **180** is larger than an external diameter of the elastic member **190**.

A first end of the conductive member **180** is spaced from the upper plunger **110** as much as a predetermined gap G, and a second end thereof contacts the lower plunger **120**. When an external force is applied, the opposite ends of the conductive member **180** may be spaced from the upper and lower plungers **110** and **120**. If the external force is applied, i.e., only when the semiconductor device **10** moves downward and presses the upper plunger **110**, the gap between the upper and lower plungers **110** and **120** is reduced and the opposite ends of the conductive member **180** may contact the upper and lower plungers **110** and **120**.

As shown in FIG. **8**, a probe **100***d* according to a fifth exemplary embodiment of the present invention includes an upper plunger **110***a* which moves up and down; the lower plunger **120**; the elastic member **140** which elastically biases the upper and lower plungers **110** and **120** to have them spaced from each other; the conductive member **150**; and a barrel **130***a*.

While the upper plungers **110** according to the first through fourth exemplary embodiments are adhered to the barrel **130**, the upper plunger **110***a* according to the present exemplary embodiment may move up and down with respect to the barrel **130***a*.

The barrel **130***a* movably accommodates therein the upper plunger **110***a* and the lower plunger **120**.

The barrel **130***a* further includes a tip **133** which is inwardly bent to prevent the upper plunger **110***a* from being separated upward.

Upon receiving a pressure, the upper plunger **110***a* moves downward, and a conic elastic member contact **115** of the upper plunger **110***a* contacts the conductive member **150**. Accordingly, the test signal (current) is transmitted to the upper plunger **110***a* through the lower plunger **120**, the barrel **130***a*, the conductive member **150** and the elastic member **140**.

As shown in FIG. **9**, a probe **100***e* according to a sixth exemplary embodiment of the present invention includes an upper plunger **110***a* which moves up and down; the lower plunger **120**; the elastic member **140** which elastically biases the upper and lower plungers **110***a* and **120** to have them spaced from each other; the conductive member **170**; and the barrel **130***a*.

Although a few exemplary embodiments have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these exemplary embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims and their equivalents.

What is claimed is:

1. A probe which electrically connects a semiconductor device and a tester for testing the semiconductor device, the probe comprising:

an upper plunger which is configured to be electrically connected to the semiconductor device;

a lower plunger which is configured to be electrically connected to the tester;

an elastic member which is disposed between the upper plunger and the lower plunger, and elastically biases the upper and lower plungers to have them spaced from each other;

a conductive member which is disposed in an inside or outside of the elastic member and electrically connects the upper plunger and the lower plunger; and

a barrel which accommodates therein the upper plunger, the lower plunger, the elastic member and the conductive member,

wherein upon non-testing, the conductive member is not contacted with one of the upper plunger and the lower plunger,

wherein upon testing, the conductive member is contacted with the upper plunger and the lower plunger so that a conductive path is formed among the upper plunger, the conductive member and the lower plunger.

2. The probe according to claim **1**, wherein the conductive member electrically connects the upper and lower plungers only when at least one of the upper plunger and the lower plunger moves toward the other one of the upper plunger and the lower plunger.

3. The probe according to claim **1**, wherein the conductive member selectively contacts at least one of the upper plunger and the lower plunger.

4. The probe according to claim **3**, wherein the conductive member applies an elastic force to at least one of the upper plunger and the lower plunger to have them spaced from each other.

5. The probe according to claim **4**, wherein the conductive member comprises at least one of a conductive coil spring and a conductive rubber.

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